CHAPTER 5 — FEATURES CONSIDERED FOR USE IN ADDRESSING PROJECTED WATER SHORTAGES

INTRODUCTION

The possible actions summarized here are described as “features” rather than “alternatives” because choosing any one of these does not preclude choosing others as well. Each of the alternatives described in chapter 6 combines three or more of these features, and other combinations are also feasible.

For each of the features described below, Reclamation personnel have estimated what effect it would have on the projected M&I shortages described in chapter 2. Most shortage figures given here are defined as "driest year" or "worst year" shortages; these represent the difference between the projected year-2050 water demands and the estimated supplies available during the driest year of the 54-year historical record. For the basin as a whole, that year was 1934, and so all basin-wide figures are relative to the conditions of 1934. At some individual localities, though, other years were drier (e.g., 1937 at Grafton and Drayton, 1940 at Fargo and Valley City), and so "worst year" shortages for those places are relative to the conditions of those other years.

Estimated construction costs are given for all features, and some also show the costs of ongoing operations and maintenance (O&M). O&M was estimated, especially, for all features carried forward into the alternatives described in chapter 6.

MODEL ASSUMPTIONS

Rivers are inherently complex natural systems, and the inclusion of municipal and industrial water systems along the rivers adds an extra layer of complexity. Even the best hydrologic models cannot reflect this degree of complexity and must embody some simplifying assumptions in order to remain workable. In an effort to provide some optimization for each feature described here, and to limit the size and cost of each feature, the HYDROSS model was set up so that upstream cities would receive priority from newly developed water. In turn, this allowed for more upstream return flows to occur and be used by downstream cities. One consequence of this assumption is that model runs for some features (e.g., features 1, 2, and 13) show no reduction of shortages for certain downstream communities, such as Drayton and Grafton, even though the features provide several thousands of acre-feet of additional water for points farther upstream.

Another assumption made in all model runs for this chapter was that intakes and outflows for all municipal systems would be no different than they are today. Repeatedly, therefore, the model simulations show that flow enhancements on the Sheyenne River would provide no additional water for the City of Moorhead because, as of today, Moorhead has no access to Sheyenne River water. Moorhead officials point out, however, that the City of Fargo's raw-water line from the Sheyenne passes within 1,500 feet of Moorhead's pumping plant, and it's easy to envision that the two systems could be interconnected prior to the year 2050. To address this possibility, HYDROSS runs for the alternatives in Chapter 6 modeled Fargo, Moorhead, and West Fargo as one single M&I demand center.

FEATURE 1, ENLARGEMENT OF LAKE ASHTABULA

Description

Lake Ashtabula is a storage reservoir on the Sheyenne River north of Valley City (figure 5.1). It is impounded behind the Baldhill Dam, built by the U.S. Army Corps of Engineers in 1950. Currently the reservoir is 27 miles in length, covers 5,234 acres, and has a maximum capacity of 68,600 acre-feet at a pool elevation of 1,266 feet. Under present operating rules, the Corps maintains a minimum pool elevation of 1,257 feet, which retains about 30,000 acre-feet in the reservoir. Due to the effects of sedimentation, these maximum and minimum water volumes are expected to decrease to about 66,600 and 28,000 acre-feet, respectively, by the year 2050.

Raising the height of Baldhill Dam by approximately 16 feet would increase the reservoir's total storage capacity to 190,000 acre-feet. No change to the minimum pool is considered as part of this feature (cf. feature 4).

Effect on Projected Shortages

The effectiveness of this feature alone in reducing projected shortages would depend on how full the reservoir is at the beginning of the modeled drought period. Two different starting conditions were simulated in HYDROSS models, yielding the following results:

Starting with reservoir at maximum (190,000 acre-feet):

- Total M&I shortage for driest year reduced by 31,500 acre-feet.
- All municipal shortages eliminated except at Moorhead.
- Industrial shortages eliminated at future plants 4 and 5.
- Shortages unaffected at Moorhead and at industrial plants 1, 2 and 3 (only because all of these draw their water from the Red River, upstream from the mouth of the Sheyenne).

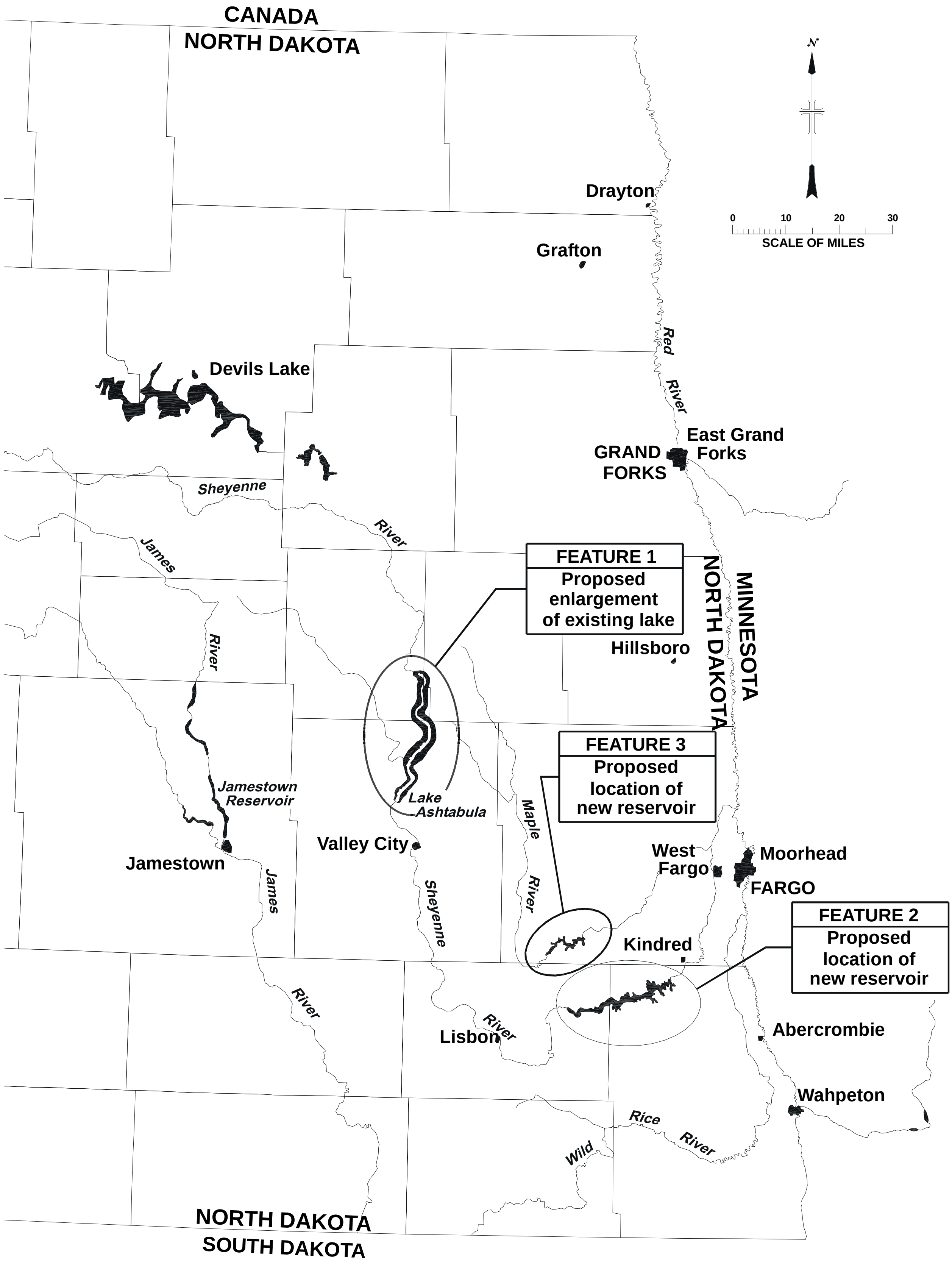

Figure 5.1.—Features 1, 2, and 3.

Starting with reservoir at minimum (28,000 acre-feet):

! Total M&I shortage for driest year reduced by 3,100 acre-feet.
! Municipal shortages eliminated only at Lisbon and Valley City.
! Zero reduction in industrial shortages.
! Worst-year shortage reduced 11 percent at Fargo and 40 percent at West Fargo.
! Shortages unaffected at Moorhead, Drayton, and Grafton.

Cost

Estimated construction costs for the modeled 190,000-acre-foot reservoir total $60.6 million. This includes $27 million for enlarging the dam and building a new spillway (including $2 million for overtopping protection; see appendix 2) plus $33.6 million for acquisition of land and buildings, relocation of lakeside facilities, and reconstruction of the existing bridges across the lake.

Annualized capital costs (over 50 years at an interest rate of 6 f percent) would be about $4.33 million per year, and O&M costs would be close to $0.18 million (extrapolated from an estimate of $120,000 for the 115,000-acre-foot reservoir described for alternative 3 in chapter 6). Thus total annualized costs are about $4.5 million.

Use in Alternatives

A variation of this feature is used in alternative 3 (chapter 6). However, model studies for that alternative determined that, if rural demands are included along with the M&I demands, then the largest useful size for Lake Ashtabula would be 115,000 acre-feet, as no larger reservoir would completely fill at any time during the critical drought period.

FEATURE 2, NEW RESERVOIR ON SHEYENNE RIVER NEAR KINDRED

Description

A new reservoir could be constructed on the Sheyenne River southwest of Kindred (figure 5.1), capable of storing as much as 180,000 acre-feet of water. The most likely dam site is in northern Richland County, about 2½ miles south of State Highway 46 and 3½ miles east of State Highway 18. The resulting reservoir would back up about 18 miles to the west-southwest, extending a few miles into Ransom County, and would be about 1½ miles across at its widest point. No "minimum pool" requirement is considered as part of this feature.

Effect on Projected Shortages

The effectiveness of this feature alone in reducing projected shortages would depend on how much water is stored—not only in the new reservoir but also in Lake Ashtabula—at the beginning of the modeled drought period. Two different starting conditions were simulated in HYDROSS models, yielding the following results:

Starting with both Lake Ashtabula and the new Kindred reservoir at maximum (68,000 and 180,000 acre-feet, respectively):

! Total M&I shortage for driest year reduced by 31,500 acre-feet.
! All municipal shortages eliminated except at Moorhead and Grafton.
! Industrial shortages eliminated at future plants 4 and 5.
! Shortages unaffected at Moorhead and at industrial plants 1, 2 and 3 (only because all of these draw their water from the Red River, upstream from the mouth of the Sheyenne).
! Grafton shortage unaffected.

Starting with both Lake Ashtabula and the new Kindred reservoir at minimum (28,000 and 0 acre-feet, respectively):

! Total M&I shortage for driest year reduced by 26,000 acre-feet.
! Municipal shortages eliminated only at Lisbon and Valley City.
! Zero reduction in industrial shortages.
! Worst-year shortages reduced 86 percent at Fargo and 60 percent at West Fargo.
! Shortages unaffected at Moorhead, Drayton, and Grafton.

Cost

Estimated construction costs total $86.5 million. This includes $62 million for initial construction, $20.56 million for land acquisition and relocation of existing facilities, and $3.96 million for recreation facilities and fish stocking. Over 50 years at an interest rate of 6 f percent, this converts to an annualized cost of $6.17 million. O&M costs are estimated at $300,000 per year, which brings the total annual cost to $6.47 million. (See appendix 2.)

Use in Alternatives

A variation of this feature is used in alternative 2 (chapter 6). However, model studies for that alternative determined that, if this feature is used in conjunction with a ring dike on the Red River, the maximum Lake Kindred storage required to meet the projected shortages would be 84,000 acre-feet. Initial costs for this scaled-down version of the reservoir were estimated at $58.4 million — $51.1 million for construction and $7.3 million for land acquisition, etc. Annual O&M was estimated at $208,500, which, when added to the annualized capital costs of $4.37 million, gives a total annual cost figure of $4.58 million.

FEATURE 3, NEW RESERVOIR ON MAPLE RIVER

Description

A new reservoir could be constructed on the Maple River (figure 5.1), which flows into the Sheyenne near West Fargo. HYDROSS sizing runs suggested the maximum effective capacity of such a reservoir would be 40,400 acre-feet. However, the most likely site yet identified (in southern Cass County about 4 miles south of Chaffee) may be limited to about 22,000 acre-feet of conservation storage if flood-control requirements are considered. Nevertheless, a capacity of 40,400 acre-feet was used for the model runs, in case another, larger storage site can be found on the Maple. No "minimum pool" requirement is considered as part of this feature.

Effect on Projected Shortages

The effectiveness of this feature alone in reducing projected shortages would depend on how much water is stored—not only in the new reservoir but also in Lake Ashtabula—at the beginning of the modeled drought period. Two different starting conditions were simulated in HYDROSS models, yielding the following results:

Starting with both Lake Ashtabula and the new Maple River reservoir at maximum (68,000 and 40,400 acre-feet, respectively):

- Total M&I shortage for driest year reduced by 27,550 acre-feet.
- Municipal shortage eliminated only at Grafton.
- Worst-year shortages reduced 39% at Fargo, 78% at Lisbon, 23% at Valley City, and 10% at West Fargo.
- Industrial shortage at future plant 4 reduced 67%.
- Shortages unaffected at Moorhead, Drayton, and industrial plants 1, 2, 3, and 5.

Starting with both Lake Ashtabula and the new Maple River reservoir at minimum (28,000 and 0 acre-feet, respectively):

- Total M&I shortage for driest year reduced by 16,160 acre-feet.
- Municipal shortage eliminated only at Grafton.
- Worst-year shortages reduced 39% at Fargo, 78% at Lisbon, 23% at Valley City, 10% at West Fargo, and 67% at future processing plant 4 near Drayton.
- Shortages unaffected at Moorhead and Drayton.

Cost

Estimated costs for dam construction, land acquisition, relocation of existing facilities, recreation facilities, and fish stocking total $40.7 million. (See appendix 2.) This cost, however, is based on the largest project feasible at the site south of Chaffee (22,000 acre-feet), which would not allow for a reservoir of the size modeled here. Annualized capital costs for this smaller reservoir (over 50 years at 6 f percent interest) come to $2.90 million, and annual O&M is estimated at $90,000, bringing total annual expense to $2.99 million.

Use in Alternatives

Because no suitable site for the larger reservoir could be identified, and because of reported high manganese levels in the water of the Maple River, this feature was not used in any of the alternatives described in chapter 6.

FEATURE 4, SUPPLY WATER FROM SHEYENNE OR MAPLE RIVER TO UPPER RED

Description

Without an additional pipeline to the Upper Red River, no water-supply improvements on either the Sheyenne or Maple River will have any effect on shortages at Moorhead, at the existing Cargill plant, and at the projected future plant near Abercrombie. These entities all draw their water from the Red River upstream from the mouth of the Sheyenne. The shortages for these three places total 1,810 acre-feet in the driest month, which would be equivalent to a constant flow of 29.5 cfs. Three variations of a "linking" pipeline to the Upper Red are described here and mapped in figure 5.2:

Feature 4A, Kindred to Wahpeton.—Water would be diverted from the Sheyenne River southwest of Kindred and sent via pipeline to the Red River near Wahpeton (approximately 32 miles).

Feature 4B, Maple River to Wahpeton.—If the Maple River Reservoir (feature 3) is built, a pipeline could carry some of its water to the vicinity of Wahpeton (approximately 51 miles).

Feature 4C, Kindred to Wahpeton and Abercrombie.—A pipeline similar to feature 4A could be built with a smaller branch off to the east, to serve future processing plant 3 near Abercrombie (about 41 miles of pipeline altogether).

Effect on Projected Shortages

These features produce no water themselves, but they would allow water stored or imported by other features to be applied to shortages on the Upper Red. In particular, feature 4A or 4C could be used in conjunction with feature 1, 2, 7, 13A, or 14. Feature 4B would be used only in combination with feature 3.

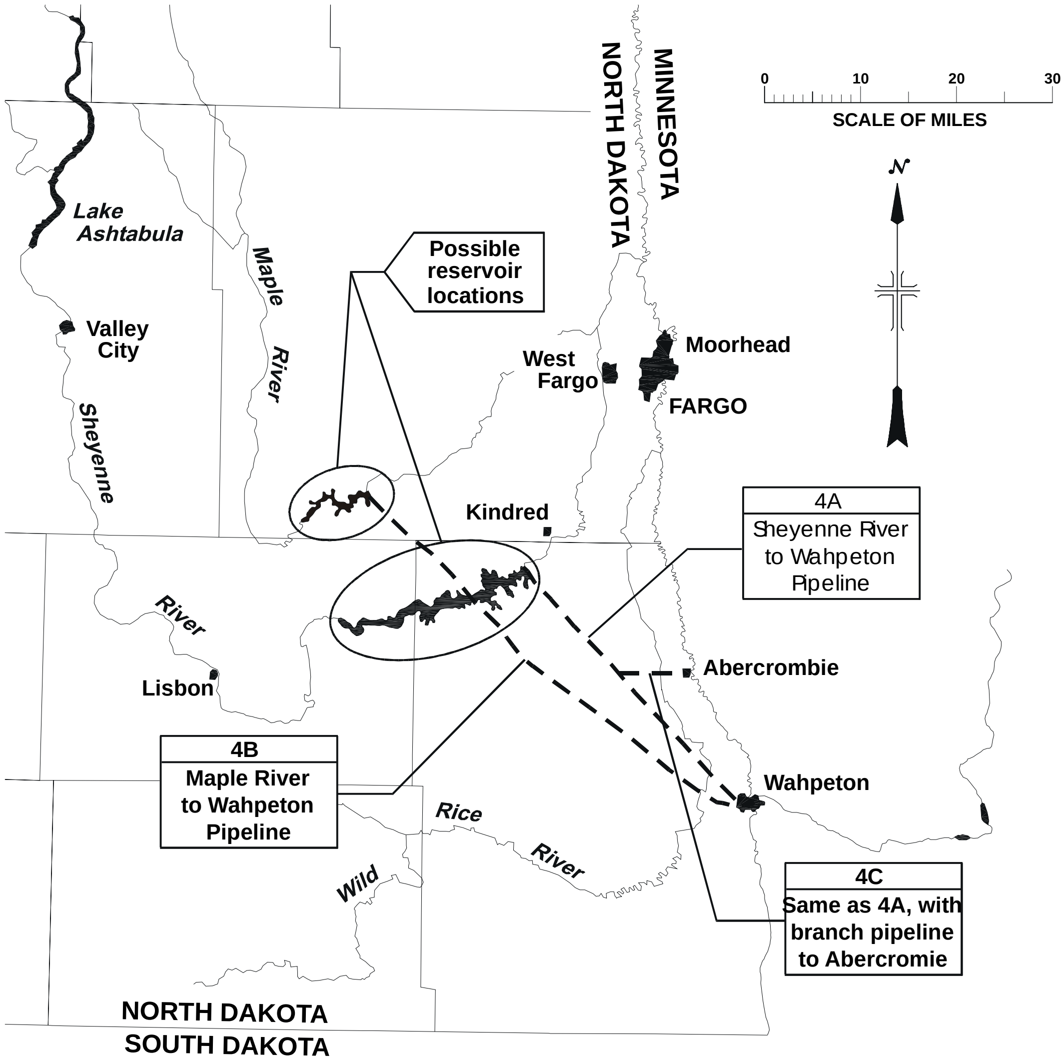

Figure 5.2.—Features 4A, 4B, and 4C

Cost

As shown on the estimate worksheets in appendix 2, the estimated construction costs for the modeled pipelines and pumping plants (30 cfs) are as follows:

Feature 4A — $47 million
Feature 4B — $71 million
Feature 4C — $54 million

No O&M costs were estimated for any of these 30-cfs pipelines. However, they were estimated for the 18-cfs version described below. For that smaller pipeline, the estimated construction cost is $44 million and estimated O&M costs are $440,000 per year. Total annualized costs come to $3.58 million.

Use in Alternatives

A downsized version of feature 4C was carried forward for use in several alternatives (chapter 6), after further modeling studies found that a constant import of 18 cfs would be sufficient to alleviate shortages on the upper Red River.

FEATURE 5, OFF-STREAM STORAGE NEAR FARGO

Description

A ring-dike reservoir could be constructed on some of the flat, open land near Fargo and used to store water during times of high runoff for use during later dry periods. The stored water could be used as a supply for Fargo, West Fargo, or possibly Moorhead. The dike would be about 20 feet high and would hold a body of water 16–17 feet deep. As shown in the "Cost" section below, various areal extents may be considered.

The water to fill the reservoir would come from excess flows, which might be available for only a few weeks each year, and it would need to be pumped up from the river channel. Therefore, a high-capacity pumping plant will be needed. Reclamation estimates, for instance, that filling a 22,000-acre-foot reservoir within 30 days would require a 400-cfs pumping plant.

Effect on Projected Shortages

As a single, stand-alone feature, used only to capture and store water from high flows, the largest of the modeled ring dikes (22,000 acre-feet) would reduce total M&I shortages in the driest year about 10,400 acre-feet. However, the ring dike could also be used to reregulate imported water and might thereby reduce the dimensions and cost of an import feature.

Cost

Table 5.1 shows estimated costs for reservoirs ranging from 2,600 to 22,000 acre-feet. Detailed estimates of construction costs are shown in appendix 2. Land acquisition costs are based on a conservative estimate of $1,500 per acre (a review of recent sales suggests that regular farm land in this area, not adjacent to a river or highway, now sells for about $1,000– 1,200 per acre). Included in the same column are relocation costs, estimated at $50,000 per quarter section (or per quarter square mile).

Use in Alternatives

All ring-dike reservoirs currently included in alternatives are of the largest size (22,000 acre-feet). Those shown on the Red River in alternatives 2, 3, and 4 include 400-cfs pumps, as

Table 5.1.—Estimated construction and annual costs for ring-dike reservoirs in the Red River Valley.

Areal extent (square miles)	Volume of water (acre-feet)	Estimated construction costs ($ millions)				Annual costs ($ millions)		
		Land & relocation	Reservoir	Pumping plant	Total	O&M	Capital †	Total
0.25	2,600	0.3	8.3	*	*	*	*	*
0.5	5,200	0.6	12.7	*	*	*	*	*
1	10,600	1.2	17.8	16.5 (200 cfs)	35.5	0.15	2.53	2.68
2	22,000	2.3	26.5	28 (400 cfs)	56.8	0.22	4.05	4.27

* Not estimated.
† Annualized capital costs over 50 years at 6 f percent interest.

modeled here, but alternative 4 also includes a second reservoir on the Sheyenne River, which would only have a 200-cfs pump, because historical high flows on the Sheyenne would not sustain a 400-cfs withdrawal. In alternatives 5 and 6, ring-dike reservoirs without pumps are used to reregulate imported flows at the ends of pipelines. In addition to these, a smaller, 10,600-acre foot version is suggested as a possible add-on to alternative 3.

FEATURE 6, PURCHASE OF SURFACE-WATER IRRIGATION RIGHTS

Description

The acquisition of irrigation rights would mean water that is now diverted to irrigate fields would be available in times of drought to meet municipal and industrial needs. This feature considers the purchase all existing irrigation rights along the main stems of both the Red and Sheyenne Rivers.

Effect on Projected Shortages

! Total M&I shortage for driest year reduced by 3,330 acre-feet.
! Shortage eliminated at Lisbon.
! Worst-year shortages reduced about 40 percent at West Fargo, 21 percent at Valley City, and only 1 percent at Fargo.
! Worst-year industrial shortage reduced 25 percent at new industry #5 near Kindred.
! No reduction of shortages at any other municipalities or industrial plants.

Cost

The cost of acquiring irrigation rights is equivalent to the difference between the values of irrigated land and dry land. Some irrigation operators may agree to sell their water rights directly; others may insist on selling the land as well, in which case the land can be resold for grazing or dryland farming. Either way, the net cost of the irrigation rights is estimated at $1,000 an acre ($1,500 irrigated value minus $500 dryland value). Lands with existing surface-water irrigation rights along the Sheyenne and Red Rivers total 11,577.6 acres. (See list in appendix 1.) If all of these rights could be acquired for $1,000 an acre, the resulting cost would be about $11.6 million. This corresponds to an annualized capital cost (over 50 years at 6 f percent interest) of $827,000.

Use in Alternatives

This feature was not incorporated in any of the alternatives, primarily because the supply of surface irrigation water would not be reliable in times of drought. The full volume of these existing irrigation rights totals more than 13,000 acre-feet, but in dry years, when the water is most needed, the actual amount delivered would be much less than this.

FEATURE 7, SECURE ADDITIONAL UNAPPROPRIATED GROUNDWATER

Description

Several shallow aquifers underlie the western side of the Red River basin, and all of them are already being tapped to provide groundwater for irrigation, rural households, and rural and small-community water systems. Three large and conveniently located aquifers that might have some additional capacity are the Sheyenne Delta, Page/Galesburg, and Spiritwood Aquifers. However, based upon the level of existing use and appropriations, the Sheyenne Delta and the Page/Galesburg aquifers are not good candidates for any sizable future withdrawals. On the other hand, the Spiritwood aquifer still has some areas that are only sparsely utilized.

The Spiritwood Aquifer System occupies a series of braided channels that extends generally south-southeastward from Towner County, on the Canadian border, to Sargent County on the border of South Dakota. It is estimated to cover about 1,600 square miles, and its top is generally 50 to 100 feet below the ground surface. Water levels in the aquifer have remained stable in recent years in spite of annual withdrawals of approximately 34,000 acre-feet for irrigation and small-community water supplies.

Additional groundwater withdrawals may be feasible in one area of the aquifer that has few existing permits. This area is in northwestern Barnes County between Leal and Dazey. The amount of groundwater drawdown created by this new withdrawal would need to be limited to protect the existing water users. The drawdown limit would also limit the total volume of water that could be withdrawn to meet a future municipal or industrial demand. The Spiritwood well field yield estimate is based upon 15 wells manifolded together to provide one supply line, resulting in a maximum capacity of 4,500 gpm. The wells are assumed to operate 11 months of the year with one month down time for maintenance. This operation could provide as much as 6,660 acre-feet of water per year.

Effect on Projected Shortages

The well field is assumed to operate continuously to provide 6,660 acre-feet per year, even in the driest years. With sufficient supply piping, this additional resource could be used to meet the combined shortages projected for several rural water systems or to reduce the total M&I shortages.

Cost

The construction cost estimate—including land acquisition, 15 new wells, pumps, connection piping, and a transmission pipe to Lake Ashtabula—is $25.5 million. The annualized capital cost (over 50 years at 6 f percent interest) is $1.82 million. The annual O&M is estimated at $514,000, bringing the total annual costs to $2.33 million (appendix 2).

Use in Alternatives

This feature is included as part of alternatives 3 and 4, which are both efforts to meet all shortages without an import.

FEATURE 8, PURCHASE EXISTING GROUNDWATER RIGHTS

Description

Due to the level of appropriation of the existing aquifers, some consideration has been given to the amount of water that could be gained by purchasing irrigation water rights. A municipality could purchase the entire water right and would have control over the land. The land could be leased back for grazing or dryland farming; however, the municipality would control agrochemical uses in order to protect the quality of the ground water supply. Any additional water obtained in this way either could be applied to a city's own water shortages or could be used to offset the city's share of Lake Ashtabula water, which might be sold or traded to other municipalities.

Aquifers considered for water rights purchase were the Sheyenne Delta and Page/Galesburg for the Fargo municipal area, and the Elk Valley aquifer for the Grand Forks municipal area.

Effect on Projected Shortages

Because of many uncertainties about the availability of water rights, we provide only an order-of-magnitude estimate of how much water might be gained under this feature. The estimate is based on the assumptions that (1) not many irrigation operators would be willing to sell the water without selling the land for a premium price and (2) municipalities would only be interested in buying larger irrigation appropriations (150 ac-ft per year or more). For estimating purposes, it is assumed that about one-third of the land owners would be willing to sell for a price of at least 150% of current market value. Therefore, from a list of those who hold large irrigation water rights, one-third of the names were randomly selected. This random selection provided site locations, thereby allowing estimates of the pipe lengths required to move water from the various wells to a main transmission point. The transfer from irrigation use to municipal use also included a reduction of the annual irrigation appropriation to 60% of its present level, because it is the usual practice of the State Water Commission to reduce the size of appropriations under these circumstances. This reduced appropriation allows the municipality to pump water year-round, rather than pumping only during the summer months, as irrigators do.

Using these assumptions, the annual yields from purchased irrigation rights are estimated to be 2,580 acre-feet for the Sheyenne Delta aquifer, 3,330 acre-feet for the Page/Galesburg, and 2,780 acre-feet for the Elk Valley, a total of 8,690 acre-feet. This amount of water could be applied to the M&I shortages or could be used to meet rural water system shortages.

Cost

The cost estimates for this feature, shown in table 5.2, are based on the purchase of all the acreage associated with each randomly selected water right for a net price of $1,000 per acre . It also includes the cost of new wells and of the collector and transmission piping used to move the water to a water system or surface stream. Operation and energy costs are based on an assumption that each individual well operates 11 months per year (even though the overall system runs continuously 12 months per year).

Table 5.2.—Estimated construction and annual costs for converting currently appropriated groundwater in the Red River Valley to municipal use

Aquifer	Construction Costs (millions of dollars)			Annual Costs (millions of dollars)		
	Initial Construction	Land & Relocation	Total	O&M	Capital[1]	Total
Sheyenne Delta	5.5	3.26	8.76	0.12	0.63	0.75
Page/Galesburg	29.0	5.92	34.92	.24	2.49	2.73
Elk Valley	25.0	5.54	30.54	.23	2.18	2.41
Totals	59.5	14.72	74.22	.59	5.29	5.88

[1] Annualized capital costs over 50 years at 6 f percent interest.

Theoretically, the cost could be partially offset by revenues gained from leasing back the land for dryland farming or pasturage. However, the municipality would restrict agrochemical use in order to protect the quality of the ground water supply, and it is unknown how much these restrictions might reduce the value of such a lease. Therefore, no estimated lease payments have been included as an offset to the original purchase price.

Use in Alternatives

Like feature 8, this feature is also included in alternatives 3 and 4, which are both efforts to meet all shortages without an import.

FEATURE 9, USE AQUIFERS FOR WATER STORAGE AND RECOVERY

Description

Under a program of aquifer storage and recovery, water collected during wet seasons would be treated and then pumped into an aquifer through injection wells. While stored underground, the water would be protected from evaporation and from the growth of light-dependent bacteria. When later withdrawn, it would need little additional treatment. This process depends upon both a supply of water to use for storage and suitable aquifer characteristics for the injection and recovery of the water. The large Page/Galesburg and Sheyenne Delta aquifers are shallow and would therefore not require great pressure to inject water for storage. Both of these aquifers, however, have water-table levels that are generally 20 feet or less below the ground surface and, hence, would have little room for added storage. The possibility of greatly increasing aquifer withdrawals in order to create storage is not considered here.

One aquifer that could be considered for a storage and recovery project is the West Fargo North aquifer. The aquifer is a confined system and, due to some significant groundwater withdrawals, has developed an area that is no long under confined conditions. The unconfined volume of the aquifer is generally centered under West Fargo and extends several miles north and south. The advantage of using the unconfined area is that water can be injected at low pressure to fill the aquifer voids, which would provide a much greater volume of storage than is attainable through high-pressure injection into a confined aquifer. The area of the West Fargo North aquifer that is currently “dewatered” is irregularly shaped, due to the changes and dips in the aquifer confining layers, and is not large. A rough estimate of its volume is on the order of 8,000 to 10,000 acre-feet, based on an assumed porosity of 10 percent. This volume changes over time, as the groundwater system responds to further withdrawals and recharge.

The uncertainties associated with an aquifer storage and recovery project cannot be overcome without significant exploration and testing at the site. One issue that would need to be addressed is the compatibility of the recharge source water with the existing groundwater. The aquifer properties, locations, and response to site specific well installations can be best tested in a pilot project. However, the cost of such a pilot project, along with monitoring and sampling, adds considerably to the startup cost of this type of program.

Effect on Projected Shortages

Using the rough estimate of 10,000 acre-feet of aquifer storage, the shortage at West Fargo and Fargo could be reduced by 38% in the worst (driest) year. In wetter years, the aquifer storage and recovery system could supply water to meet peaking demands.

Cost

Estimated construction costs total $12.5 million.   This equates to an annualized capital cost (over 50 years at 6 f percent interest) of $891,000. The annual O&M is estimated at $390,000, bringing the total annual costs to $1.28 million.

Use in Alternatives

This feature, like the previous two, is used only in alternative 4.

FEATURE 10, DESALINIZATION OF WATER FROM THE DAKOTA AQUIFER

Description

The Dakota Aquifer is a regional bedrock system that extends westward from the Red River Valley as far as the Rocky Mountains. Its water has a high dissolved-solids content (typically in the range of 2,000 to 5,000 milligrams per liter), which exceeds the Environmental Protection Agency's "secondary maximum contaminant level" (an unenforceable advisory guideline). Most consumers would find its taste unacceptable even after conventional treatment. Desalinization plants would be needed to make the water suitable for municipal use. The most likely site for such a plant would be the Grand Forks–East Grand Forks area, because the Dakota aquifer does not extend into the Fargo-Moorhead area.

Effect on Projected Shortages

The amount of water available from the Dakota Aquifer is limited primarily by the aquifer's low yield rate. Boysen et al.[1] estimated that an array of three wells would be able to produce as much

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[1] Boysen, J.E., J.A. Harju, C. Rousseau, J. Šolc, and D.J. Stepan. [Undated.] Evaluation of the natural freeze-thaw process for the desalinization of groundwater from the Dakota aquifer to provide water for Grand Forks, North Dakota. U.S. Bureau of Reclamation, Water Treatment Technology Program, Lakewood, CO.

as 1 million gallons per day (1 MGD≈1.5 cfs). If such an array were operated 95 percent of the time, year round, it could produce 1,064 acre-feet per year. Presumably, two such arrays, if widely enough separated, could produce about 2,128 acre-feet per year.

If this water were produced in the Grand Forks–East Grand Forks area, it would have no effect on shortages there because these cities have no projected shortages. Therefore, the efficacy of this feature would depend on the reallocation of a portion Grand Forks' Lake Ashtabula water rights to other cities and industries upstream.

Cost

Cost estimates have been prepared for processing Dakota Aquifer water by a reverse-osmosis treatment process and for disposing of the resulting brine. Table 5.3 summarizes both construction and operations costs for treatment plants running at either 1 or 2 MGD, and producing water with a total dissolved solids content of either 300 or 500 mg/L. These cost estimates assume that water would be blended to achieve the stated TDS targets. The amount of untreated water blended into the effluent flow would be 9 percent for a target of 500 mg/L and 4.9 percent for a target of 300 mg/L. All costs are appraisal level and are represented in December 1998 dollars. Additional costs not included are building construction costs, NEPA environmental study costs, and water system storage and distribution costs. See appendix 2 for more details.

Use in Alternatives

This feature, like features 7, 8, and 9, is used only in alternative 4.

Table 5.3.—Summary of Costs Associated with Treatment of Dakota Aquifer Water

Capacity (MGD)	Effluent TDS (mg/L)	Capital Costs ($ millions)					Annual Costs ($ millions/yr)		
		Wells & pumps	Desal. plant [1]	Land & relocation	Brine disposal	Total	O&M	Capital [2]	Total
1	500	0.20	2.23	0.02	21.30	23.75	0.32	1.69	2.01
	300	.20	2.26	.02	21.30	23.78	.32	1.70	2.02
2	500	.28	3.68	.02	36.38	40.36	.46	2.88	3.34
	300	.28	3.73	.02	36.38	40.41	.47	2.88	3.35

[1] Desalinization plant costs obtained using Draft Water Treatment Cost Estimation and User Manual by Michelle Chapman Wilbert, Bureau of Reclamation Water Treatment Technology Program.
[2] Annualized capital costs over 50 years at 6 f percent interest.

FEATURE 11, REUSE MUNICIPAL WASTEWATER FOR URBAN IRRIGATION

Description

Treated municipal wastewater could be used for irrigation of municipally owned parks, golf courses, and recreation fields and of some country clubs, cemeteries, and other private lands. Many of these areas currently irrigate with water from municipal distribution systems, and others divert river water for the purpose. In both cases, substituting treated wastewater would reduce the amount of water taken out of the rivers. This section evaluates the feasibility of reusing wastewater from the cities of Fargo, Moorhead, and Grand Forks.

Effect on Projected Shortages

HYDROSS modeling for this feature yielded the following results:

- Total M&I shortage for driest year reduced by 380 acre-feet.
- Shortages reduced only about 1 percent at Fargo, Moorhead, and West Fargo.
- No reduction of shortages at any other municipalities.

Cost

Estimated costs of installing the necessary pumps and pipelines to bring recycled wastewater to the irrigated areas total $19.7 million ($11 million for Fargo and $8.7 million for Grand Forks). No O&M costs were estimated.

Use in Alternatives

Because this feature has such a small effect on the projected shortages, it was not incorporated in any of the alternatives described in chapter 6.

FEATURE 12, INCREASE WATER CONSERVATION MEASURES

Description

The water conservation program envisioned for this feature represents a balanced program, intended to be implemented and maintained on a long term basis, while being continually modified to best address the individual conservation goals of each municipality. It is left to the municipalities to evaluate their individual circumstances and develop water conservation programs that address their specific needs and opportunities to conserve water.

An effective water conservation program usually includes measures that address both demand and supply management. Typical conservation plan components are listed below.

Supply management programs typically include:

- o Metering all customers, meter testing and replacement programs
- o Controlling and reducing, where possible, the maximum pressure in water delivery systems, and regulating pressure to new subdivisions
- o Active water audit and leak detection, repair and replacement programs
- o Water reuse

Demand Management programs typically include:

- o Active public education, outreach and demonstration programs
- o Education about and enforcement of existing plumbing codes or development of additional codes
- o Encouraging or requiring low-water-use landscaping, efficient irrigation, and irrigation designs for new developments
- o Retrofitting kits and/or programs to lower interior water use in existing homes, or rebates for the installation of new water conserving fixtures;
- o Conservation-oriented rate structures (both supply and wastewater) to provide incentives for efficient water use.

Municipalities should especially focus on implementing ways to reduce future outdoor water use, in places such as lawns, parks, and golf courses, to reduce demand peaks during dry periods. This can help to significantly reduce peaking demands and delivery system capacity problems during drought periods.

Effect on Projected Shortages

It is estimated that through planned water conservation programs, water demand by municipalities in the valley can be reduced an average of 15 percent from the demands projected by Reclamation for the year 2050. This can be accomplished by a three-pronged conservation program that (1) maintains future residential and commercial water use at their present levels, (2) reduces projected industrial water use by 15% while maintaining projected levels of output, and (3) reduces or maintains public water use and water losses to 10 percent of total water treated. HYDROSS modeling based on the assumption of a 15% reduction in demand yielded the following results:

- ! Total M&I shortage for driest year reduced by 14,200 acre-feet.
- ! Municipal shortage eliminated at Valley City.
- ! Percentage reductions of other municipal shortages as follows: Drayton, 17; Fargo, 35; Moorhead, 25; Grafton, 17; Lisbon, 67; and West Fargo, 44.
- ! Industrial shortages reduced approximately 15 percent at all five processing plants.

Cost

Water conservation programs are not free. However, municipalities can design and package conservation programs to meet their specific needs, budgets, and opportunities so that the local benefits of the program will meet or exceed costs. This is generally the case even if one disregards the benefits of reduced capital investments for new or expanded raw-water and wastewater treatment facilities.

An evaluation of the conservation programs of the cities of Grand Forks and Moorhead, as contained in their 1995 *Water Emergency and Conservation Plans*, indicates that costs ranged from 6 to 8 dollars per capita for a mix of supply and demand conservation measures. Assuming a projected study area population of 395,870 by the year 2050, the annual conservation program cost will be approximately $2.8 million to save about 17,000 acre-feet each year. Stated differently, it would cost 50 cents to conserve 1,000 gallons of water or $165 to conserve an acre-foot, which is about one-fourth of the rate at which water is presently billed.

Use in Alternatives

Conservation is an integral part of all alternatives—even the "no action" alternative 1. However, the descriptions in chapter 6 show no specific water savings or reduction in demand due to conservation for the following reason: Reclamation's projected future demands were based on *average* annual demands. These made no allowance for variations in annual demand, which can increase 15 to 20 percent above the average during dry years. It is anticipated that these dry-year increases would be mostly offset by an active water conservation program, bringing these peak dry-year demands down close to the average demand projection. In other words, in order to incorporate the effects of water conservation in these alternatives the study team decided *not* to model increased water demands during dry years.

FEATURE 13, DROUGHT CONTINGENCIES

Feature 13A, Eliminate Minimum Pool of Lake Ashtabula

Description

Lake Ashtabula is a storage reservoir on the Sheyenne River north of Valley City. It is impounded behind the Baldhill Dam, built by the U.S. Army Corps of Engineers in 1950. Currently the reservoir is 27 miles in length, covers 5,234 acres, and has a maximum capacity of 68,600 acre-feet at a pool elevation of 1,266 feet. Under present operating rules, the Corps maintains a minimum pool elevation of 1,257 feet, which retains about 30,000 acre-feet in the reservoir. Due to the effects of sedimentation, these maximum and minimum water volumes are expected to decrease to about 66,600 and 28,000 acre-feet, respectively, by the year 2050. The feature considered here is the elimination of the minimum pool requirement, to allow use of all water from the lake in times of critical drought.

Effect on Projected Shortages

HYDROSS modeling for this feature yielded the following results:

- Total M&I shortage for driest year reduced by 3,540 acre-feet.
- Municipal shortages eliminated at Lisbon and Valley City.
- Shortages reduced 40 percent at West Fargo and 13 percent at Fargo.
- Shortages unaffected at Drayton, Grafton, and Moorhead.
- No effect on industrial shortages

Cost

As this feature requires no change in present facilities and only minor changes in procedures, startup costs would be negligible. However, it would result in a periodic complete loss of the Lake Ashtabula fishery and all associated recreational activities. The estimated cost for restocking the fishery is about $2 million, but the loss of recreation-related spending at local businesses is estimated at more than $35 million.

Feature 13B, Emergency Reductions in Municipal Demands

Description

This drought contingency planning feature is intended to illustrate the contribution that drought management would have towards reducing water supply shortages for municipalities in the study area. The conservation measures described here are more severe than those discussed for Feature 12 and would be implemented only temporarily, in response to a drought emergency. Feature 12 described a permanent, ongoing water conservation program.

Drought contingency plans generally take the form of a phased response to increasingly more severe water-supply shortages or projected shortages. A typical plan might identify three or four levels of severity (i.e., mild, moderate, severe, and extreme) and identify conservation measures applicable to each level. In addition, a drought contingency plan requires the identification of a set of trigger or threshold conditions that indicate when response measures may need to be put into effect. The development of a drought contingency plan should include extensive public input to assure an equitable plan that is likely to be accepted and voluntarily implemented.

"Mild" condition measures generally include active public information programs to encourage voluntary reduction of water use. "Moderate" condition measures typically include a mix of voluntary conservation and some mandatory restrictions on nonessential uses. "Severe" condition measures may include additional mandatory restrictions, the outright prohibition of some specific types of water use, fines for violations, and the establishment of special pricing structures designed to reduce water demand. "Extreme" condition measures may include prohibitions of more types of water use (i.e., any outdoor use), and rationing of customer water use, particularly industrial and commercial use, so the remaining water is available of essential uses.

Trigger conditions for implementing the various levels of measures will vary for each municipality depending on historic demand patterns, delivery system capacities, reserve groundwater supplies, reservoir storage rights, and direct-flow water rights. A mild drought response might be triggered while water supplies are still adequate, if the water levels of reservoirs are low and water managers see a possibility that a continuation of the drought may lead to shortages. Each municipality may define its own “impact levels” for declining river flows, reservoirs, and wells, which would trigger increasingly harsh drought responses. Impact levels that trigger a moderate or severe drought response levels might be those indicating the possibility that a continued drought may lead to a critical or extreme situation. An extreme level of response would be triggered as river and water supply storage levels decline to a level beyond which the system is in imminent danger of major failure.

Water use reduction goals for the four levels of severity will also vary for municipalities depending on particular circumstances and opportunities for conservation. General demand reduction goals fall within the following ranges: Level I, mild conditions—5 to 15 percent; Level II, moderate conditions—10 to 25 percent; Level III, severe conditions—20 to 40 percent; Level IV, extreme conditions—25 percent and up.

Drought Contingency Planning for the Red River Valley

The following conceptual drought contingency plan is described here for discussion and evaluation purposes. It is assumed here that all the municipalities in the valley will be equally and simultaneously impacted by a drought; therefore, changes in water demand are considered valley-wide. This conceptual drought plan is not intended to represent a specific drought management plan for any of the municipalities in the valley.

For this evaluation, a four-level conceptual drought response is considered, targeting the following emergency demand reductions:

Level I, mild conditions—5 to 10 percent,
Level II, moderate conditions—10 to 20 percent,
Level III, severe conditions—20 to 30 percent,
Level IV, extreme conditions—30 percent and up.

Level I, Response to a mild drought condition.—This first level of response would be triggered by an early indication of a possible supply shortage, such as when projections of water supply and municipal demands indicate a likelihood that continued drought conditions could cause Lake Ashtabula to be drawn down to its current minimum pool elevation of 1,257 feet. The Level I response goal for this feature would be to reduce demand by 5-10 percent. Typical response measures might include:

1. Informing the public through mail and news media that a trigger condition has been met and that water users should look for ways to reduce water use.
2. Activating an information center.
3. Reminding the public of the trigger condition daily.
4. Advertising a voluntary daily lawn watering schedule.
5. Encouraging voluntary reductions in nonessential uses.

Level II, Response to a moderate drought condition.—This second level of response would be triggered when a combination of high water demands and decreasing storage in Lake Ashtabula indicate a high likelihood that the lake level will be drawn below the current minimum pool level. The Level II response goal for this feature will be a 10-20 percent demand reduction. Typical response measures for this level of severity might include:

1. Mandatory implementation of a lawn-watering schedule.
2. Prohibiting certain nonessential uses (e.g., ornamental water fountains; flushing of gutters; or washing down of buildings, parking lots, driveways, and sidewalks)
3. Mandatory restrictions of other types of nonessential water use.

Level III, Response to a severe drought condition.—This level of response would be triggered when the water surface elevation of Lake Ashtabula reaches 1,257 feet, which is the current minimum pool elevation under the present operating rules. At this elevation, about 28,000 acre-feet of water remains in the lake. The Level III demand reduction goal is 10 percent on top of the previous 10-20 percent Level I and Level II reductions, for a total response demand reduction goal of 20-30 percent. Typical Level III response measures include:

1. Continuation of Level I and II measures.
2. Assessing fines to water wasters.
3. Requesting industries and nonmunicipal water users to eliminate certain uses, to find alternative supplies of water, or to recycle water.
4. Prohibiting all outdoor water use.

Level IV, Response to an extreme drought condition.—This level of response would be reached when water supplies are so limited that the failure of the supply system is imminent. The Level IV demand reduction goal is an additional 10 percent (or more) over the previous reductions of 20-30 percent, for a total response demand reduction goal of 30 percent or greater. Response measures may include:

1. Water rationing—limiting the amount of water each customer can use and taking legal action as needed to assure compliance.
2. Curtailing industrial and some commercial uses.
3. Reserving supplies for essential health- and safety-related uses.

Discussion

It is important to consider that droughts are typically brought about by unusually warm and dry weather conditions. These conditions tend to simultaneously produce a two pronged impacts: (1) reduced river flows and a resulting reduction in water supplies, and (2) increased water demands, mostly for outdoor uses. Municipalities in the study generally receive enough rainfall during the spring and summer so that outdoor water use makes up a relatively small component of their annual water use. However, lawns that are seldom irrigated during average or wet years, may require continuous irrigation during dry periods, resulting in a considerable increase in water demand. Cities in more arid parts of the country would probably not see such a drastic increase in outdoor water demand, as lawns in those places are normally irrigated throughout the spring and summer. The impact of increased water demand for outdoor uses in the study area can be significant.

Examination of the City of Moorhead's water demand during the drought year of 1988 showed an increased per capita demand of over 20 percent, compared to 10-year average between 1985 and 1994. According to a city official, Moorhead was not facing a supply shortage in 1988 but did implement voluntary response measures as a show of support to residents in the neighboring city of Fargo, which had implemented mandatory restrictions at the time.

The City of Grand Forks experienced a similar situation, except that its driest year was 1989. Per capita water demand in 1989 increased by about 15 percent, compared to the 11-year average from 1984 through 1994. According to city officials in Grand Forks, the city did not implement a formal drought response that year, but did turn to the news media to encourage lawn watering only every second day.

Effect on Projected Shortages

Based on the cases above, it is expected that during dry and hot weather conditions, typical of drought situations, water demand in the valley would increase by about 15 to 20 percent above that of an average year, even with implementation of some voluntary drought response measures. This increase in demand would probably more than offset the demand reduction accomplished by achieving the overall water conservation goal of 15 percent as discussed in Feature 12. Therefore, it is likely that water demands during a drought year, even with water conservation, will be higher than Reclamation's projected average year demand. Activation of a Level I drought response, in addition to a fully implemented water conservation program (Feature 12), may necessary to ensure that water demands during a drought do not exceed those projected by Reclamation for an average year.

Activation of a Level II drought response, targeting an overall goal of reducing demand by 10-20 percent, may reduce actual demands by as much as 10 percent below those of an average year. Similarly, activation of Level III and Level IV drought responses may reduce demand by as much as 20 and 30 percent, respectively, below Reclamation's projected average demand.

Water supply shortages indicated by model runs utilizing Reclamation's average year water demand projections should therefore represent actual M&I demands during periods of drought. This assumes that municipalities will have implemented a Level I drought response on top of an ongoing, fully implemented water conservation program. Activation of additional levels of drought response, as well as use of the minimum pool in Lake Ashtabula, are considered a contingency against future droughts more severe than those contained in the 54 year period of record.

Cost

The additional cost of implementing a drought contingency plan has not been estimated. The actual costs of implementing the plan are likely to be low, but the resulting economic impact may be significant. Evaluation of this impact is beyond the scope of this study.

Use in Alternatives

The study team attempted to reserve both of these features as drought *contingincies*, to be used in the event that a drought is more severe than the one modeled here or in case some features produce less water than projected. They found, however, that Feature 13A had to be included in Alternative 3 in order to meet all projected shortages. Neither Feature 13A nor 13B was incorporated in any other alternatives in chapter 6.

FEATURE 14, IMPORT MISSOURI RIVER WATER TO UPPER SHEYENNE RIVER

Description

The partially constructed Garrison Diversion Unit could be used to import Missouri River water to the upper Sheyenne River in central Eddy County. This feature has three possible configurations (figure 5.3):

14A. Pipeline from McClusky Canal to New Rockford Canal via Missouri Coteau route; treatment at end of New Rockford Canal; second pipeline from end of New Rockford to Upper Sheyenne.

14B. Pipeline from McClusky Canal to New Rockford Canal via Northern Route; treatment at end of New Rockford Canal and possibly also at McClusky Canal (milepost 59); second pipeline from end of New Rockford to Upper Sheyenne.

14C. Pipeline direct from McClusky Canal to Upper Sheyenne; treatment at McClusky Canal.

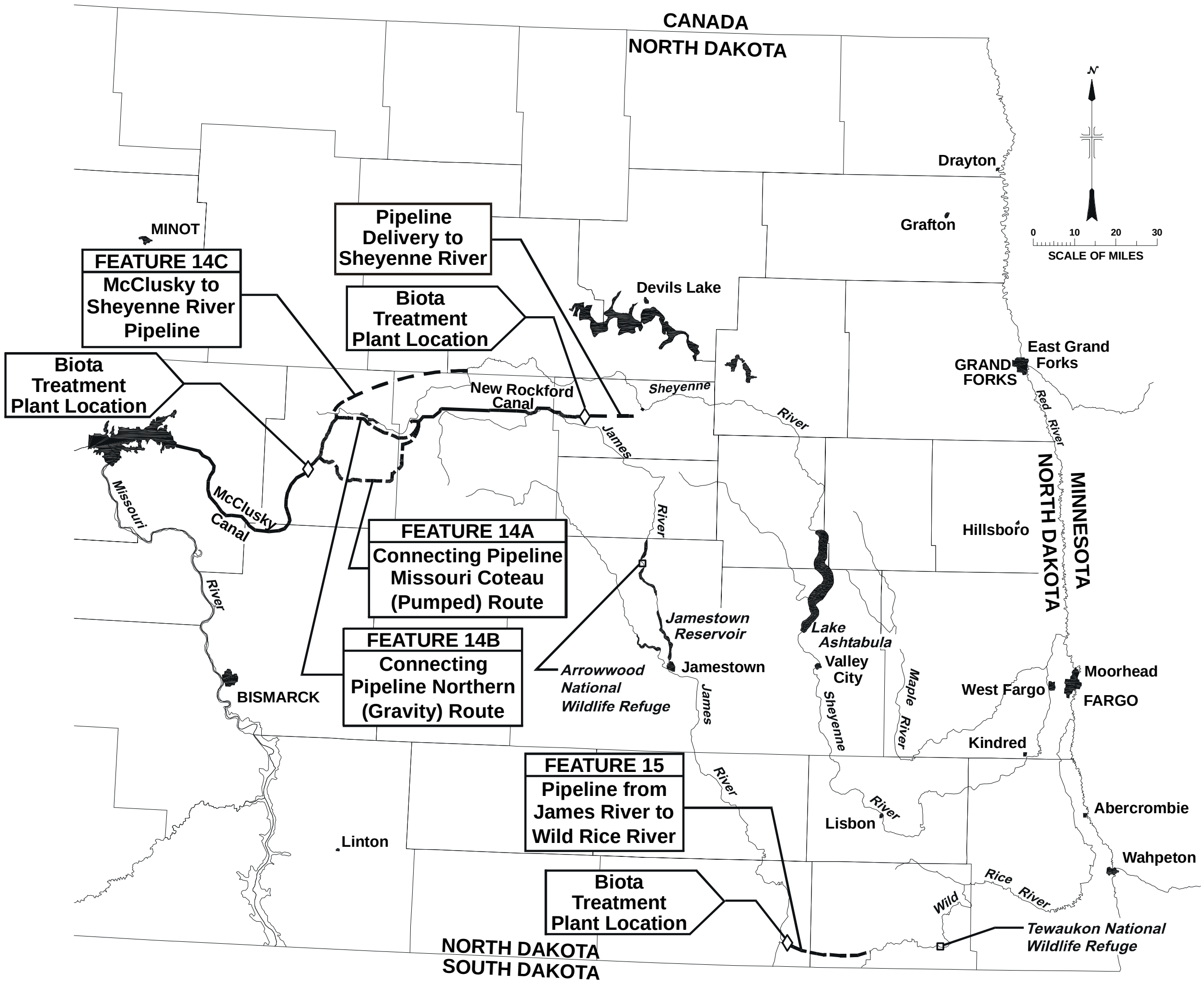

Figure 5.3.—Features 14A, 14B, 14C, and 15

The design of these features is complicated by the need for sterilization of any water transferred from the Missouri Basin to the Red River Basin. Features 14A and 14B both move water first to the New Rockford Canal and then to the Sheyenne River. In 14A, the McClusky-to-New Rockford pipeline would be 35 miles long and would require pumping. In 14B, this pipeline would be only 22 miles long and would flow by gravity. However, the entire route of the 14A pipeline is within the Missouri Basin, whereas the 14B pipeline crosses the divide onto the Red River side and then crosses back to the Missouri side. Because pipelines may leak, some authorities propose that any water following the 14B route should be treated twice: first at the intake on the McClusky Canal (at mile post 59) and again at the end of the New Rockford Canal. Under 14A, treatment is needed only at the latter point. The final link to the Sheyenne River, used in both 14A and 14B, is a 9.3-mile pipeline.

Feature 14C would be a single pipeline, approximately 34 miles in length, directly from the McClusky Canal to the confluence of the North and South Forks of the Sheyenne River. Water would be treated on the McClusky Canal and would flow by gravity to the Sheyenne. The pipeline could be of smaller diameter than either of the McClusky-to-New Rockford links, because it would not have to accommodate losses in the New Rockford Canal. (Reclamation personnel estimate that any flow directed through the New Rockford would need to be about 15 cfs greater than the intended discharge to the Sheyenne, to allow for seepage, spillage, evaporation, and other losses.)

Effect on Projected Shortages

Regardless of which configuration is used, HYDROSS modeling shows the following results for any import that supplies a peak capacity of at least 58 cfs to the Upper Sheyenne:

- Reduces total M&I shortage for driest year by 31,520 acre-feet.
- Eliminates all M&I shortages, except for those at Moorhead and three of the five modeled processing plants.
- The city of Moorhead, the present Cargill plant near Wahpeton, and future processing plants 2 and 3 near Abercrombie and Fargo receive no additional water, only because they draw their water from the Red River upstream from the mouth of the Sheyenne.

If used in combination with either feature 4A or 4C, this feature could also address shortages on the Upper Red River.

Cost

Estimated costs depend on (1) which pipeline route is selected, (2) what flow rate the system is designed to accommodate, and (3) whether pretreatment is accomplished by the ozone/ chloramine/dechlorination (O/C/D) process or by the chlorine/chloramine/dechlorination (C/C/D) process (see chapter 4).

Cost estimates for any of these options also have to include the costs of certain repairs and maintenance to the existing Garrison Diversion infrastructure. These include $42 million required under all configurations ($5.1 million for dredging the intake channel to the Snake Creek pumping plant and $36.9 for repairs to the McClusky Canal) plus another $15.9 million that would be needed under either 14A or 14B ($8.9 million for repairs to the New Rockford Canal and $7 million for constructing a New Rockford Canal overflow outlet). The range of estimates for capital construction costs, O&M, and total annual costs is shown in table 5.4.

Treatment costs for feature 14B are higher than those for the other options because the estimates include the cost of two treatment plants, one of which would have a flow rate 15 cfs higher than the flow delivered to the Sheyenne.

Table 5.4.—Construction, O&M, and Total Annual Costs for Feature 14 Import Configurations

Pipeline route	Flow delivered to Sheyenne River (cfs)	Treatment process	Estimated construction cost (millions of dollars)				Estimated annual costs (millions of dollars)		
			Existing infrastructure	Pipelines and pumping plant	Water treatment plant(s)	Total	O&M	Annualized capital costs	Total
Missouri Coteau route (14A)	135	O/C/D	57.9	150	23.0	230.9	4.72	16.47	21.19
		C/C/D	57.9	150	12.0	219.9	3.85	15.68	19.53
	100	O/C/D	57.9	126	18.0	201.9	3.70	14.40	18.10
		C/C/D	57.9	126	8.6	192.5	3.05	13.73	16.78
	60	O/C/D	57.9	101	12.4	171.3	2.54	12.22	14.76
		C/C/D	57.9	101	4.8	163.7	2.16	11.67	13.83
Northern route (14B)	135	O/C/D	57.9	97	48.1	203.0	4.31	14.48	18.79
		C/C/D	57.9	97	25.4	180.3	2.47	12.86	15.33
	100	O/C/D	57.9	83	38.2	179.1	3.33	12.77	16.10
		C/C/D	57.9	83	18.7	159.6	1.94	11.38	13.32
	60	O/C/D	57.9	62	26.9	146.8	2.19	10.47	12.66
		C/C/D	57.9	62	11.0	130.9	1.33	9.33	10.66
Direct pipeline (14C)	135	O/C/D	42	99	23.0	164.0	2.14	11.70	13.84
		C/C/D	42	99	12.0	153.0	1.27	10.91	12.18
	100	O/C/D	42	88	18.0	148.0	1.64	10.56	12.20
		C/C/D	42	88	8.6	138.6	1.00	9.88	10.88
	60	O/C/D	42	64	12.4	118.4	1.08	8.44	9.52
		C/C/D	42	64	4.8	110.8	.70	7.90	8.60

Use in Alternatives

Three of the four “suboptions” for alternative 7 were built around the three configurations described for this feature: chapter 6 shows the inclusion of feature 14A in alternative 7A, 14B in alternative 7C, and 14C in alternative 7B. These alternatives also incorporate feature 4C to carry water to the upper Red River. Under this configuration, HYDROSS modeling showed 72 cfs to be the optimal import size, so new cost estimates were prepared based on that flow rate. Only the O/C/D water-treatment process is considered in the alternatives.

FEATURE 15, IMPORT MISSOURI RIVER WATER TO WILD RICE RIVER

Description

Missouri River water would be imported first to the James River, by way of the New Rockford Canal, and then pumped to the Wild Rice River through a 36-mile pipeline in the southern parts of Dickey and Sargent Counties (figure 5.3). (The Wild Rice flows eastward to the vicinity of Wahpeton and then turns northward, paralleling the Red River for about 30 miles before finally joining it south of Fargo.) Here, too, the water would need to be treated to eliminate Missouri Basin biota.

The first step, importing water to the James River, requires a connecting pipeline to the New Rockford canal, similar to feature 14A or 14B but without the final 9-mile pipeline to the Sheyenne.

Effect on Projected Shortages

HYDROSS modeling for this feature, using a maximum import capacity of 31 cfs, yielded the following results:

- Total M&I shortage for driest year reduced by 49,300 acre-feet.
- Shortages eliminated at Drayton, Fargo, Moorhead, and Grafton and at four of the five modeled industrial plants.
- Shortages unaffected at Lisbon, Valley City, West Fargo, or future processing plant 5 near Kindred. (These places all draw water from the Sheyenne River and hence are unaffected by enhanced flows on the Red.)

Cost

Cost estimates were not completed for this feature; at most, a very rough estimate can be extrapolated from the available data. Appendix 2 includes a detailed estimate ($43 million) for a 20-cfs pipeline and pumping plant connecting the James River to the Wild Rice. Although the difference between that design flow and the modeled flow (31 cfs) is 55 percent, these costs cannot be prorated directly. The difference in cost is more likely to be in the range of 20 to 40 percent. Arbitrarily increasing the estimate by 30 percent yields a figure of $55.9 million for the pipeline and pumping plant. Based on the formulas given in chapter 4 (graphs 1 and 3), estimated construction costs for a 31-cfs treatment plant would be either $8.27 million for O/C/D treatment or $1.94 million for C/C/D. Rounding to the nearest million, this yields a rough estimate of either $64 million or $58 million for the James-to-Wild Rice portion of this import.

However, this feature also requires a connection from the McClusky Canal to the New Rockford Canal—similar to feature 14A or 14B but without the final pipeline to the Sheyenne and its associated water treatment plant. Losses in the James River channel have not been modeled or estimated, so it is unknown how large the import into the James would need to be. The smallest import estimated for feature 14 is 60 cfs. If one assumes that an import of that size is sufficient for this feature, then some of the estimates prepared for feature 14 may be relevant here. The total construction costs given above for a 60-cfs import using either feature 14A or 14B would be reduced by the cost of the final treatment plant and the 9-mile pipeline to the Sheyenne. This reduction amounts to $35.4 million for the O/C/D alternatives or $27.8 million for C/C/D. The resulting costs just for the import to the James range from $103.1 million (northern route, C/C/D treatment) to $135.9 million (Missouri Coteau route, without treatment).

Routing the imported flow by way of the James River leads to some additional expense: $27.5 million for stabilization of the James River channel, and $3 million for mitigation of effects at Arrowwood National Wildlife Refuge. Adding this final $30 million to the two sets of highly uncertain estimates discussed above yields an even more uncertain set of total costs for this feature that range from about $192 million to $230 million. Similar rough estimates could be made for annual costs, but no such calculations have been attempted.

Use in Alternatives

This feature was not selected for use in any of the alternatives in chapter 6, mainly because of concerns about insufficient channel capacity in the Wild Rice River and adverse environmental effects at Arrowwood, Tewaukon, and Sand Lake National Wildlife Refuges.

FEATURE 16, LAKE OAHE TO WAHPETON PIPELINE

Description

Water taken from the Missouri River south of Bismarck would be treated on site and sent via pipeline (figure 5.4) to the Red River near Wahpeton (approximately 185 miles).

Effect on Projected Shortages

Same as modeled for feature 15.

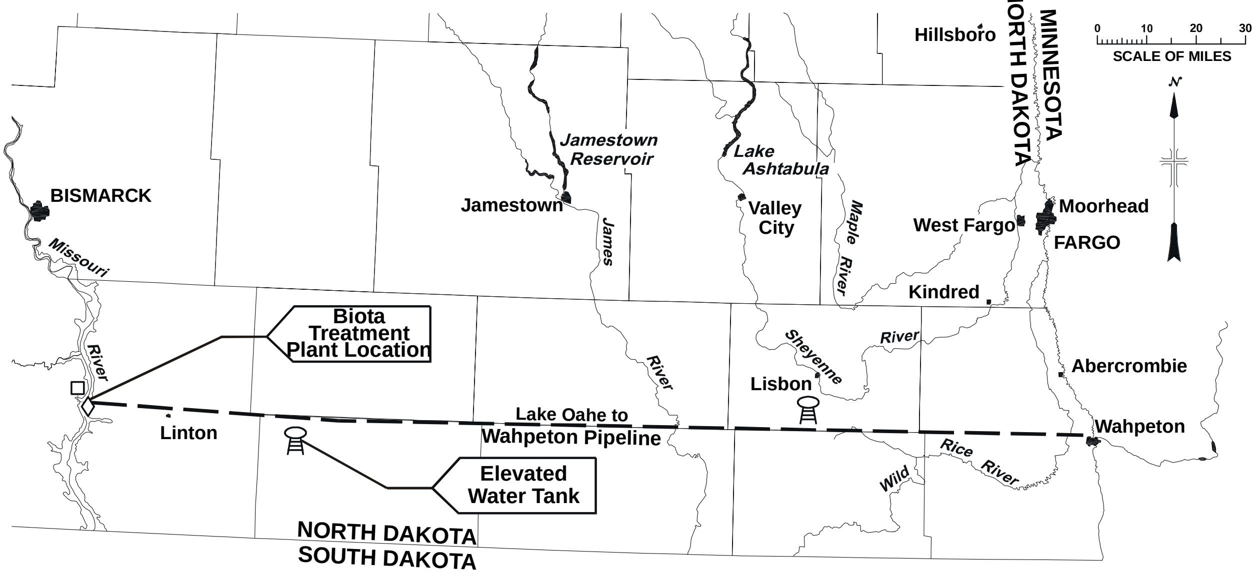

Figure 5.4.—Feature 16.

Cost

Estimated construction and annual costs are shown in table 5.5. These vary, depending on the design flow rate and on whether water treatment is accomplished by the ozone/chloramine/ dechlorination (O/C/D) process or by the chlorine/chloramine/dechlorination (C/C/D) process (see chapter 4).

Table 5.5.—Estimated construction and annual costs for Lake Oahe to Wahpeton pipeline (feature 16)

Flow rate (cfs)	Treatment process	Estimated construction cost ($ millions)			Annual costs ($ millions/yr)		
		Pipelines and pumping plant	Water treatment plant	Total	O&M	Capital[1]	Total
108	O/C/D	640	19.2	659.2	7.29	47.01	54.30
	C/C/D	640	9.4	649.4	6.60	46.31	52.91
91	O/C/D	590	16.8	606.8	6.39	43.27	49.67
	C/C/D	590	7.7	597.7	5.81	42.63	48.44
83	O/C/D	550	15.6	565.6	5.94	40.34	46.28
	C/C/D	550	7.0	557.0	5.41	39.72	45.13
68	O/C/D	490	13.5	503.5	5.11	35.91	41.02
	C/C/D	490	5.5	495.5	4.68	35.34	40.02
60	O/C/D	450	12.4	462.4	4.67	32.98	37.65
	C/C/D	450	4.8	454.8	4.29	32.43	36.72

[1] Annualized capital costs over 50 years at 6 f percent interest.

Use in Alternatives

This feature is incorporated in alternative 6. Modeling for that alternative showed that a 60-cfs import could meet all projected shortages *if* the demands for Fargo and West Fargo are transferred from the Sheyenne River to the Red River.

FEATURE 17, SERVE RURAL WATER SYSTEMS FROM RED RIVER

Description

This feature (figure 5.5) has been developed to help determine the cost and flow impacts of providing a surface water diversion for supplementing rural water system supplies. This feature would probably be used only if surface flows within the Red River Basin are augmented by imports or enhanced storage. Without an import or increased surface water storage, the added diversions to rural water systems would only increase the predicted year-2050 M&I shortages.

Of the 12 rural water systems on the west side of the Valley, 10 have predicted shortages ranging from 50 to 2,550 acre-feet per year. Predictions for Barnes Rural Water and North Valley Water Association show that their existing appropriated water supplies are adequate to meet future demands. Shortages of rural water systems have been combined in some cases in order to provide for a single diversion point. Each diversion is considered to include a pumping plant, surface water treatment plant, and pipeline delivery to a point within the individual rural water system area. The delivery point has been selected to be near an existing storage tank site or near the existing main supply well. Costs have been estimated here for some main delivery pipelines but not for associated interconnects or improvements in existing rural water infrastructure.

Using these assumptions, six diversion points have been projected for the surface water supply system (figure 5.5). The locations and maximum supply rates for these diversions are:

Agassiz, Tri-County, and Walsh Water.—A diversion on the Red River below its confluence with the Park River. The diversion would have a capacity of 545 gallons per minute (gpm) and would supply 720 acre-feet per year.

Cass Rural Water.—A diversion on the Sheyenne River near Horace. The diversion would have a capacity of 1,825 gpm and would supply 2,420 acre-feet per year.

Dakota Rural Water.—A diversion on Lake Ashtabula. The diversion would have a capacity of 665 gpm and would supply 875 acre-feet per year.

Grand Forks-Traill and Traill Water Users.—A combined diversion on the Red River upstream from the city of Grand Forks. The diversion would have a capacity of 1,985 gpm and would supply 2,615 acre-feet per year.

Langdon Rural Water.—A diversion on the Red River between Drayton and Pembina. The diversion would have a capacity of 245 gpm and would supply 320 acre-feet per year.

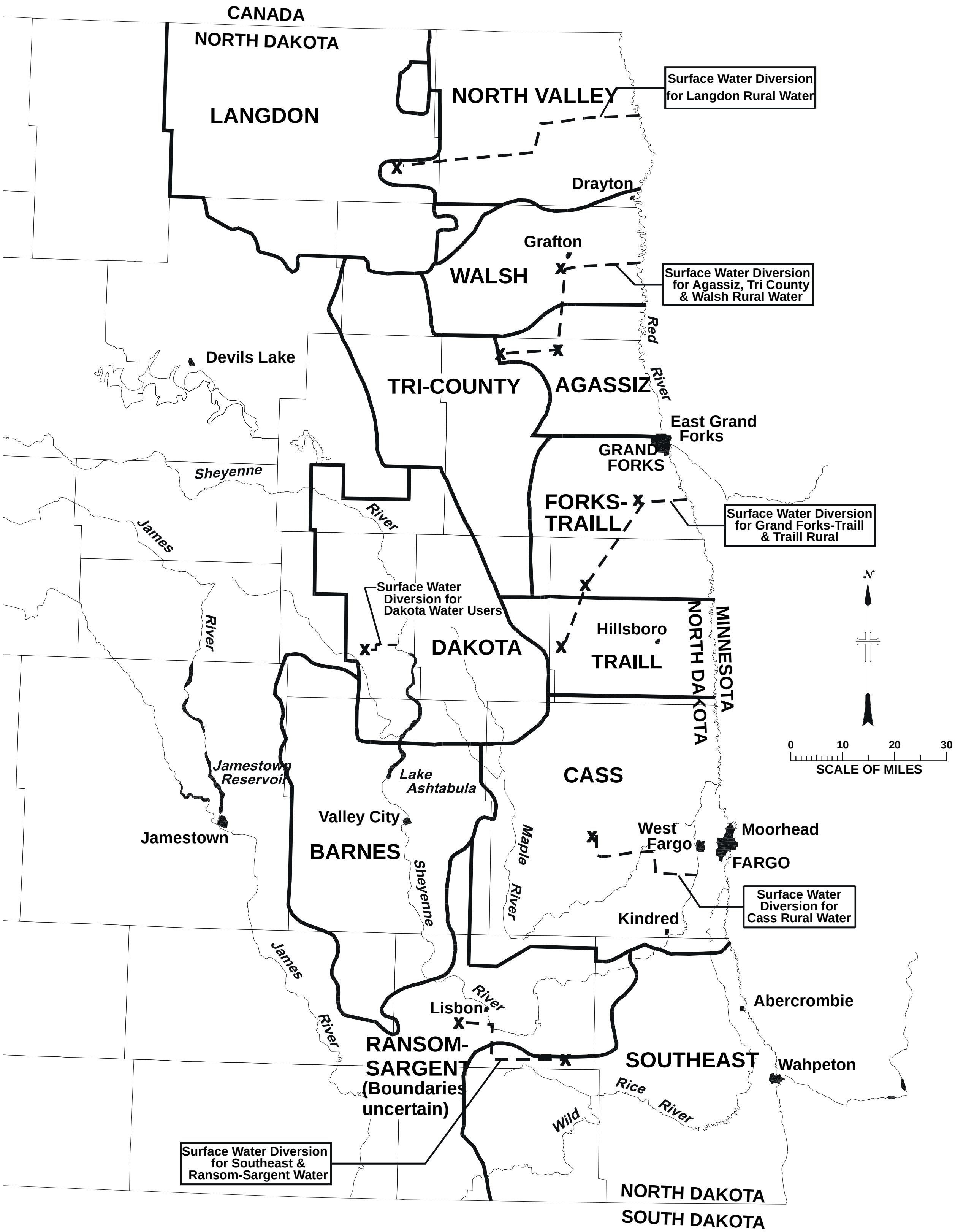

Figure 5.5.—Rural Water System Boundaries and Diversions Proposed Under Feature 17.

Southeast Water Users and Ransom-Sargent. —A combined diversion on the Sheyenne River downstream from the city of Lisbon. The diversion would have a capacity of 870 gpm and would supply 1,152 acre-feet per year.

Effect on Projected Shortages

Because the projected rural-water diversions are small (totaling 8,102 acre-feet per year) and would have a lower priority than existing municipal and industrial diversions, they would have little effect on the overall M&I shortage for the driest year. Moreover, as stated above, this feature probably would be used only in combination with an import or some other enhancement of surface-water flows.

Cost

Estimated costs for each diversion, shown in table 5.6, include the expense of a surface water pumping plant, a surface water treatment plant, and the main delivery pipeline from the treatment plant to the key point within the individual rural water system. For combined rural water system diversions, a main pipeline is routed and sized to deliver water to each individual rural water system. Costs do not include any other changes or improvements in the existing infrastructure of the rural water systems.

Table 5.6.—Estimated Construction and Annual Costs for Feature 17, Serving Rural Systems from Surface Water Supplies

Water system(s) served	Estimated construction cost (millions of dollars)			Annual costs (millions of dollars)		
	Pumps and pipelines	Treatment plants	Total	OM&R	Capital[1]	Total
Agassiz, Tri-County, Walsh	15.2	3.3	18.5	0.42	1.32	1.74
Cass Rural	13.2	7.5	20.7	.79	1.48	2.27
Dakota Rural	7.9	3.5	8.4	.44	.60	1.04
Grand Forks-Traill and Traill Water Users	11.3	8.0	19.3	.85	1.38	2.23
Langdon Rural	16.7	1.9	18.6	.32	1.33	1.65
Southeast and Ransom-Sargent	14.9	4.2	19.1	.55	1.36	1.91
TOTALS	79.2	28.4	104.6	3.37	7.47	10.84

[1]Annualized capital costs over 50 years at 6 f percent interest.

Use in Alternatives

This feature is included in alternatives 2, 4, 5, 6, and 7. It was not used in alternative 1 because that is defined as the "No Action" alternative. In alternative 3, most of these rural systems are served from newly acquired groundwater resources. In alternative 8, they are served directly from the “Western Red River Valley pipeline.”

FEATURE 18, BISMARCK-FARGO PIPELINE

Description

Water taken from the Missouri River south of Bismarck could be treated on site and pumped approximately 180 miles through a pipeline directly to the municipal distribution system at Fargo (figure 5.6). The model of this feature assumes that water supplied to Fargo would also be available to Moorhead, even though these two systems are not currently connected. Model simulations suggest that a capacity of 83 cfs would be needed during the driest month.

Effect on Projected Shortages

HYDROSS modeling shows that this feature, by itself:

- Reduces total M&I shortage for driest year by about 37,500 acre-feet.
- Eliminates municipal shortage at Fargo.
- Reduces other municipal shortages by the following percentages: Lisbon, 33; Valley City, 63; and West Fargo, 66.
- Eliminates industrial shortage for the modeled future plant #2 at Fargo, and reduces shortage at existing Cargill plant (at Wahpeton) 99 percent.
- Has no effect on projected shortages at Moorhead, Grafton, and Drayton and at the modeled future plants 3, 4, and 5.

Cost

Estimated construction and annual costs are shown in table 5.7. These vary, depending on the design flow rate and on whether water treatment is accomplished by the ozone/chloramine/dechlorination (O/C/D) process or by the chlorine/chloramine/dechlorination (C/C/D) process (see chapter 4).

Use in Alternatives

This feature is incorporated in alternative 5. Modeling for that alternative showed that a 70-cfs import could meet all projected shortages if the pipeline import is used to meet base demands at Fargo, West Fargo, Moorhead, the Cargill plant at Wahpeton.

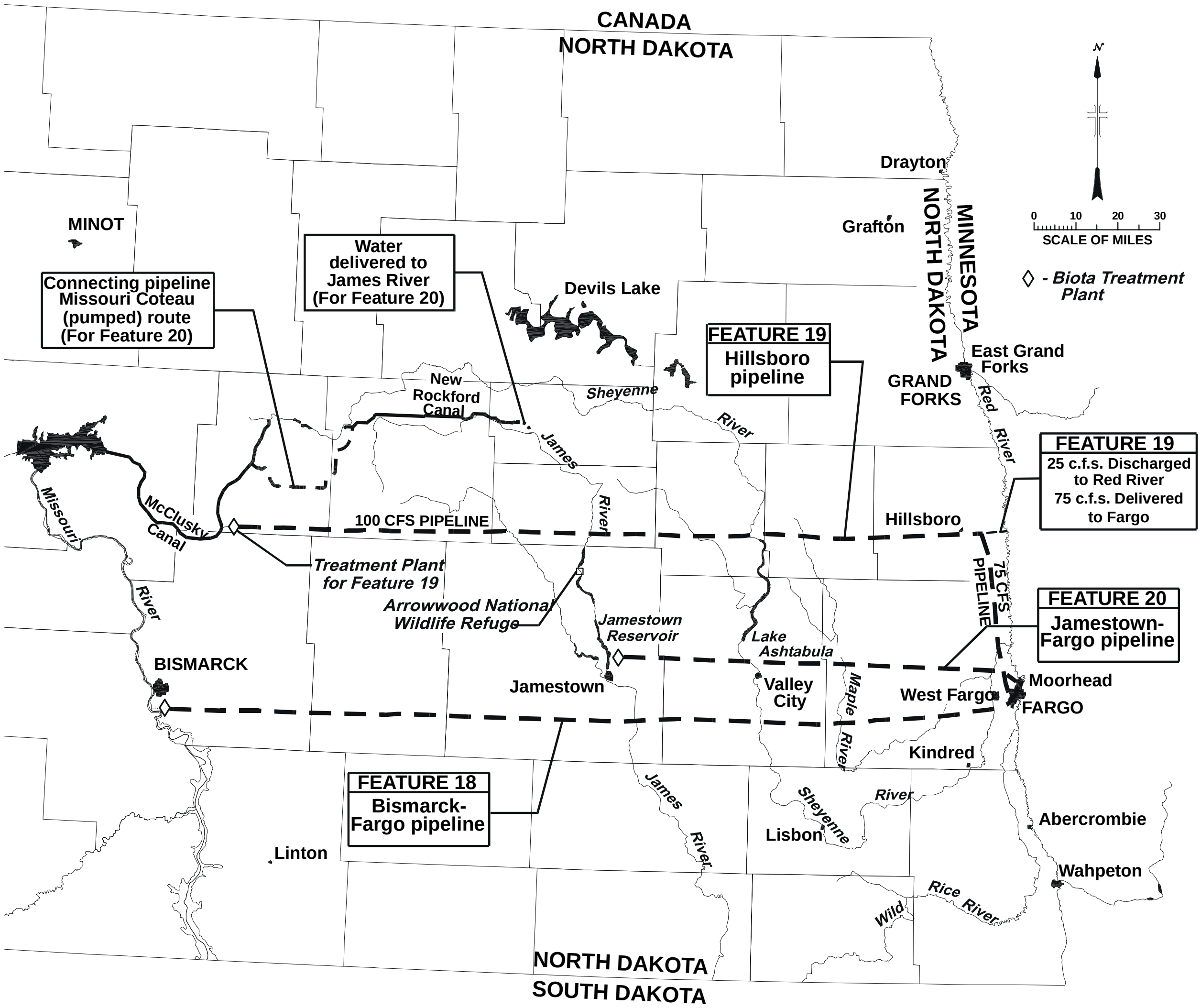

Figure 5.6.—Features 18, 19, and 20.

Table 5.7.—Estimated construction and annual costs for the Bismarck-Fargo pipeline (feature 18)

Flow rate (cfs)	Treatment process	Estimated construction cost (millions of dollars)			Annual costs (millions of dollars)		
		Pumps and pipelines	Treatment plant	Total	O&M	Capital[1]	Total
100	O/C/D	600	18.1	618.1	6.45	44.01	50.53
	C/C/D	600	8.6	608.6	5.81	43.40	49.21
70	O/C/D	490	13.8	503.8	4.93	35.93	40.86
	C/C/D	490	5.7	495.7	4.48	35.35	39.83
40	O/C/D	330	9.6	339.6	3.38	24.22	27.60
	C/C/D	330	2.8	332.8	3.13	23.74	26.86

[1] Annualized capital costs over 50 years at 6 f percent interest.

FEATURE 19, McCLUSKY CANAL TO HILLSBORO PIPELINE

Description

This feature (figure 5.6) is a followup of an alternative proposed in an earlier report by Reclamation's Dakotas Area Office.[2] The concept is an import of Missouri River water to the Red River Valley, delivered to the major municipal areas of Fargo and Grand Forks. The delivery system consists of a biota treatment plant on the McClusky Canal, from which the treated water would be pumped by pipeline to the vicinity of Hillsboro, ND (approximately 155 miles). There, the pipeline would tee, with 75 cfs of the flow delivered to Fargo (≈38 miles) and 25 cfs discharged into the Red River for diversion and use by Grand Forks and some rural systems.

During the HYDROSS model runs, the shortage demand on the Sheyenne River required an import flow of 72 cfs. When the demands for Grand Forks water quality enhancement (20 cfs) and the combined northern valley rural water systems (5 cfs) were added to the model, the import became 97 cfs. The total import should be slightly higher to account for miscellaneous river losses between the Hillsboro discharge point and the diversion at Grand Forks.

Effect on Projected Shortages

This feature alone would eliminate all projected MR&I shortages.

Cost

A worksheet included in Appendix 2 gives an estimate for a 100-cfs pipeline and associated pumping plants. However, the full cost for this feature should also include costs for the biota treatment plant, Snake Creek Pumping Plant rehabilitation, McClusky Canal repairs, surface water treatment plants and distribution lines for rural water systems (Feature 17), and a pipeline to deliver 18 cfs to the upper Red River. Table 5.8 provides the estimated cost summary for the entire supply system.

Use in Alternatives

This feature is not used in any of the alternatives in chapter 6.

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[2] Bureau of Reclamation. March 1997. *Cost Comparison, Garrison Diversion Unit*. Dakotas Area Office, Engineering & Construction Division, Bismarck, ND.

Table 5.8.—Estimated construction and annual costs for the McClusky Canal to Hillsboro pipeline (feature 19)

Facility	Construction Cost (millions of dollars)	Annual Costs (millions of dollars)		
		OM&R	Capital[1]	Total
100-cfs Pipeline & Pumps	535.86	4.18	38.21	42.39
100-cfs Biota Treatment Plant (O/C/D process)	18.05	1.47	1.29	2.76
Snake Creek Pumping Plant	5.10		.36	.36
McClusky Canal	36.90		2.63	2.63
Rural Water Distributions	81.40	.99	5.81	6.80
Upper Red River Pipeline (Fargo to Wahpeton)	69.00	.45	4.92	5.37
Totals	746.31	7.09	53.22	60.31

[1] Annualized capital costs over 50 years at 6 f percent interest.

FEATURE 20, JAMESTOWN-FARGO PIPELINE

Description

Missouri River water delivered to the James River via the New Rockford Canal could be withdrawn from Jamestown Reservoir, treated on site, and pumped approximately 90 miles through a pipeline directly to Fargo's municipal distribution system (figure 5.6). Model simulations suggest that a capacity of 68 cfs would be needed during the driest month.

Effect on Projected Shortages

Effects would be identical to those of feature 18, described above.

Costs

Construction and O&M costs for the Jamestown-Fargo pipeline portion of this feature were estimated using flow rates of 40, 70, and 100 cfs. (See worksheets in Appendix 2.) However, this feature also necessitates:

- Completion of a connection from the McClusky Canal to the New Rockford Canal (similar to feature 14A or 14B, but without the final treatment plant and the 9-mile pipeline to the Sheyenne River).

Table 5.9.—Estimated construction, O&M, and total annual costs for the Jamestown to Fargo pipeline (feature 20)

Element of Feature 20	Construction Costs in Millions of Dollars					
	40-cfs Import		70-cfs Import		100-cfs Import	
	O/C/D	C/C/D	O/C/D	C/C/D	O/C/D	C/C/D
Jamestown-Fargo Pipeline & Pumps	160	160	230	230	280	280
Biota Treatment Plant	9.5	2.8	13.8	5.7	18.0	8.6
James River Channel Stabilization	9.1	9.1	9.1	9.1	9.1	9.1
Arrowwood NWR Mitigation	3.0	3.0	3.0	3.0	3.0	3.0
Improvements to GDU Infrastructure	57.9	57.9	57.9	57.9	57.9	57.9
Subtotal	239.5	232.8	313.8	305.7	368.0	358.6
McClusky-New Rockford Pipeline via Coteau Route	[1] 78	[1] 78	[2] 99	[2] 99	[3] 115	[3] 115
Total if Coteau Route Used	317.5	310.8	412.8	404.7	483.0	473.6
McClusky-New Rockford Pipeline via Northern Route	[1] 53.5	[1] 45.2	[2] 76.2	[2] 66.1	[3] 87.1	[3] 75.4
Total if Northern Route Used	293.0	278.0	390.0	371.8	455.1	434.0

See footnotes on following page.

Element of Feature 20	O&M Costs in Millions of Dollars Per Year					
	40-cfs Import		70-cfs Import		100-cfs Import	
	O/C/D	C/C/D	O/C/D	C/C/D	O/C/D	C/C/D
Jamestown-Fargo Pipeline & Pumps	1.31	1.31	1.81	1.81	2.29	2.29
Biota Treatment Plant	.63	.38	1.05	.60	1.47	.83
Subtotal	1.94	1.69	2.86	2.41	3.76	3.12
McClusky-New Rockford Pipeline via Coteau Route	[1] 1.58	[1] 1.58	[2] 2.17	[2] 2.17	[3] 2.70	[3] 2.70
Total if Coteau Route Used	3.52	3.27	5.03	4.58	6.46	5.82
McClusky-New Rockford Pipeline via Northern Route	[1] 1.23	[1] .75	[2] 1.80	[2] 1.06	[3] 2.29	[3] 1.32
Total if Northern Route Used	3.17	2.44	4.66	3.47	6.05	4.44

See footnotes on following page.

Element of Feature 20	**Total Annual** Costs in Millions of Dollars[4]					
	40-cfs Import		70-cfs Import		100-cfs Import	
	O/C/D	C/C/D	O/C/D	C/C/D	O/C/D	C/C/D
Jamestown-Fargo Pipeline & Pumps	12.72	12.72	18.21	18.21	22.26	22.26
Biota Treatment Plant	1.31	.58	2.03	1.01	2.75	1.44
James River Channel Stabilization	.65	.65	.65	.65	.65	.65
Arrowwood NWR Mitigation	.21	.21	.21	.21	.21	.21
Improvements to GDU Infrastructure	4.13	4.13	4.13	4.13	4.13	4.13
Subtotal	19.02	18.29	25.23	24.21	30.00	28.69
McClusky-New Rockford Pipeline via Coteau Route	[1] 7.14	[1] 7.14	[2] 9.23	[2] 9.23	[3] 10.90	[3] 10.90
Total if Coteau Route Used	26.16	25.43	34.46	33.44	40.90	29.59
McClusky-New Rockford Pipeline via Northern Route	[1] 5.04	[1] 3.97	[2] 7.23	[2] 5.77	[3] 8.50	[3] 6.70
Total if Northern Route Used	24.06	22.26	32.46	29.98	38.50	35.39

[1] Assumes a 75-cfs import through the McClusky-New Rockford pipeline in order to deliver 60 cfs (after losses) to the end of the New Rockford Canal.
[2] Assumes a 115-cfs import through the McClusky-New Rockford pipeline in order to deliver 100 cfs (after losses) to the end of the New Rockford Canal.
[3] Assumes a 150-cfs import through the McClusky-New Rockford pipeline in order to deliver 135 cfs (after losses) to the end of the New Rockford Canal.
[4] Includes O&M expense, as listed above, plus the annualized capital expenditure (over 50 years at 6 f percent interest).

- $57.9 million in improvements to the Garrison Diversion Unit's infrastructure—specifically, dredging the intake channel for the Snake Creek Pumping Plant ($5.1 million), repairs to the McClusky Canal ($36.9 million), repairs to the New Rockford Canal ($8.9 million), and construction of a feeder canal to the James River ($7 million).
- $12.1 million worth of "add-on" costs for stabilization of the upper James River channel ($9.1 million), and for mitigation of effects at Arrowwood National Wildlife Refuge ($3 million).

Obviously, the initial import from the Garrison Diversion to the James would need to be larger than the final import to Fargo, but how much larger is unknown. Losses in the James River channel have not been modeled or estimated, and no special estimates have been prepared for Garrison Diversion imports sized specifically for this feature. The best cost estimates available for the McClusky-to-New Rockford pipeline are those prepared for Features 14A and 14B, which were calculated to deliver flows of 60, 100, or 135 cfs to the end of the New Rockford Canal. Therefore, table 5.9 was prepared by assuming that these three flow rates would be close to the ones actually needed in order to support an export of 40, 70, or 100 cfs, respectively, farther downstream.

Use in Alternatives

This feature is not used in any of the alternatives in chapter 6.

FEATURE 21, WESTERN RED RIVER VALLEY PIPELINE

Description

A pipeline transmission system (figure 5.7) would convey pretreated water from the New Rockford Canal to various cities, industries, and rural water districts along the Western Red River Valley.   Sizing runs showed that, in order to meet all projected shortages at these points, a

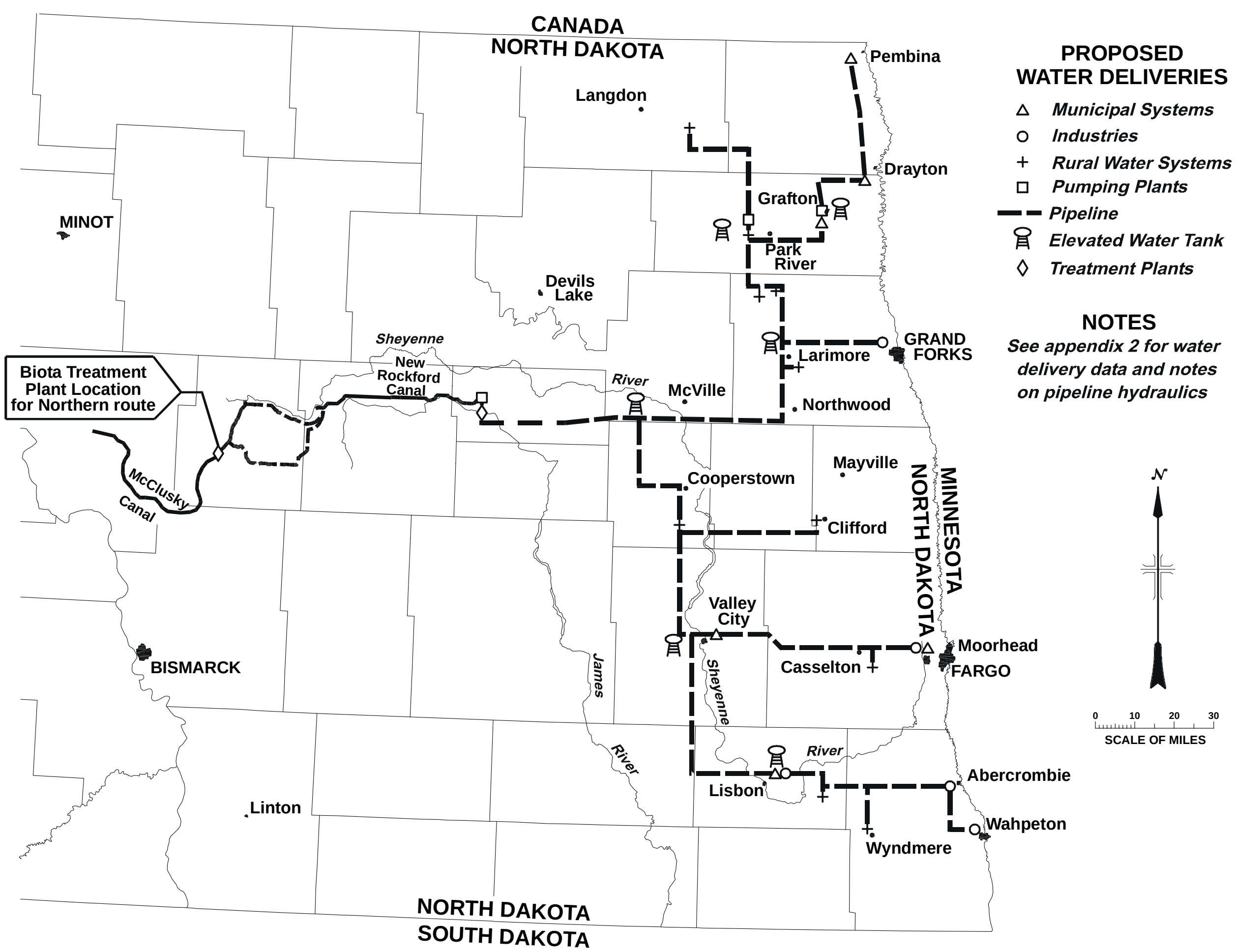

Figure 5.7.—Feature 21.

maximum outflow from the New Rockford Canal of about 84 cfs would be required. Table 5.10 lists the systems to be served and the amount of flow delivered to each.

Table 5.10.—Water systems to be served by Western Red River Valley pipeline (feature 21)

Water System(s)	Flow (cfs)
MUNICIPAL:	
Fargo/Moorhead/ West Fargo	21.3
Grafton	1.8
Grand Forks	20.0
Sum, cities	**43.1**
INDUSTRIAL:	
Cargill, Wahpeton	9
New 2, Abercrombie	9
New 5, Lisbon	9
Sum, industrial	**27**

Water System	Flow (cfs)
RURAL SYSTEMS:	
Agassiz	0.084
Cass	4.060
Dakota	1.470
Grand Forks-Trail	4.310
Langdon	0.540
SE Water Users	1.430
Trail County	0.110
Tri-County	0.790
Walsh	0.340
Ransom-Sargent	0.500
Sum, rural	**13.634**

TOTAL MR&I = 83.734 cfs

Effect on Projected Shortages

This feature alone would eliminate all projected M&I shortages.

Costs

In addition to building the distribution network described here, this feature also requires completion of the connection from the McClusky Canal to the New Rockford Canal, as described for feature 14A or 14B. Therefore, just as for those features, the projected cost of the Western Red River Valley pipeline depends on which route is selected for the McClusky-to-New Rockford link and on whether biota treatment is done by the ozone/chloramine/dechlorination (O/C/D) process or by the chlorine/chloramine/dechlorination (C/C/D) process (see chapter 4). Table 5.11 shows the range of possible costs.

Use in Alternatives

This feature is the main component of alternative 8 in chapter 6.

Table 5.11.—Estimated construction and annual costs for the Western Red River Valley pipeline (feature 21)

Element of feature 21	Construction (millions of dollars)		Annual costs (millions of dollars)					
			O&M		Capital [1]		Total	
	O/C/D	C/C/D	O/C/D	C/C/D	O/C/D	C/C/D	O/C/D	C/C/D
Main pipeline, pumps, etc.	750	750	3.44	3.44	53.49	53.49	56.93	56.93
Treatment plant	15.8	7.1	1.25	.71	1.13	.51	2.38	1.22
Existing GDU infrastructure [2]	57.9	57.9			4.13	4.13	4.13	4.13
Subtotal	**823.7**	**815.0**	**4.69**	**4.15**	**58.75**	**58.13**	**63.44**	**62.28**
McClusky-New Rockford Pipeline via Coteau Route [3]	90.6	90.6	1.93	1.93	6.46	6.46	8.39	8.39
Total if Coteau Route used	**914.3**	**905.6**	**6.62**	**6.08**	**65.21**	**64.59**	**71.83**	**70.67**
McClusky-New Rockford Pipeline via Northern Route [3]	67.1	57.7	1.57	0.94	4.79	4.12	6.36	5.06
Total if Northern Route used	**890.8**	**872.7**	**6.26**	**5.09**	**63.54**	**62.25**	**69.80**	**67.34**

[1] Annualized capital costs over 50 years at 6 f percent interest.

[2] $5.1 million for Snake Creek pumping plant intake channel, $36.9 for McClusky Canal repairs, $8.9 million for New Rockford Canal repairs, and $7 million for a New Rockford canal overflow outlet.

[3] Estimate for a 99-cfs pipeline (allowing 15 cfs for losses on the New Rockford Canal), calculated through a straight interpolation between the 75- and 115-cfs estimates prepared for feature 14. Estimate for "Northern Route" also includes cost of a 99-cfs biota treatment plant on McClusky Canal.